IN THE SPECIFICATION

Please amend the paragraph beginning at page 1, line 12, as follows:

The present invention relates to an ignition and injection control system for an internal combustion engine suitable for use in a vehicle.

Please replace the paragraph beginning at page 1, line 17, with the following rewritten paragraph:

Conventionally, an ignition control system executes a multiple electric discharges operation. In the multiple electric discharges operation, a plurality of discharges are carried out during one engine combustion cycle. For executing the multiple discharges, for example, an ECU outputs an ignition signal IGt to energize and de-energize ~~disenergize~~ the primary coil of an ignition coil repeatedly. Thereby, high voltage is introduced in the secondary coil of the ignition coil, and the ignition coil multiply discharges.

Please replace the paragraphs beginning at page 2, line 1, with the following rewritten paragraphs:

According to the example in FIG. 14, when a gasoline injection type internal combustion engine cold starts, the ignition timing thereof is retarded to 100 CA after compression top dead center, and a multiple discharges operation discharging five times is executed. Each discharge interval and discharge period are fixed. The discharge interval is set to 1 ins, and each discharge period is set to 0.4 ins. Here, the

last (fifth) discharge period is not determined. The engine ~~Engine~~ rotation number is set to 1200 rpm.

When the ignition signal IGt falls down, primary electric current i1 in the ignition coil is shut ~~hut~~ off, and secondary electric current i2 and secondary voltage V2 are introduced as shown in FIG. 14. Further, as the multiple discharges operation proceeds, the primary electric current i1, the secondary electric current i2, and the secondary voltage V2 change as shown in FIG. 14.

Here, the product of secondary electric current i2 and secondary voltage V2 corresponds to energy density. The energy density reduces as the number of discharges is increased. Since the product of energy density and discharge period corresponds to the discharge energy amount, the discharge energy amount for each discharge reduces as the discharge is repeated. However, the required energy amount for introducing a required spark at each discharge gradually increases. The required energy amount is denoted by slant lines area in FIG. 14. According to experiments conducted by the inventors, when the air-fuel ratio (A/F) of an air-fuel mixed gas is 17, the required discharge energy is 3.5 mJ at the first discharge. The required discharge energy increases as the discharge is repeated, and the discharge energy reaches 9.3 mJ at the fifth discharge. Here, the required energy density is 22 mJ/ms at the first discharge, and is 25 mJ/ms at the fifth discharge.

As is understood from the experiments, as the discharge is repeated, the energy amount introduced by discharge becomes smaller than the required energy amount. Thus, the multiple discharges operation cannot be executed.

An engine control system calculates fuel injection amount and ignition

timing. The engine controller outputs an injection signal for each cylinder into an injection operating circuit, and outputs an ignition signal for each cylinder into an ignition operating circuit, for introducing a spark discharge at each ignition plug.

However, the ignition operating circuit and the injection operating circuit are independently formed and arranged far from each other. Thus, even ~~eve~~ when there is a function device commonly used for both circuits, the function device cannot be shared ~~viewing~~ from a circuit arrangement standpoint, thereby enlarging the ~~a~~ circuit scale and increasing ~~to increase~~ the manufacturing cost.

According to the conventional engine control system, the number of signal lines, which lead ignition and injection signals from the engine control computer to each cylinder, is large. Thus, a wide wiring space is needed, and the arrangement of the signal lines becomes complicated, thereby increasing the manufacturing cost.

Please replace the paragraph beginning at page 4, line 1, with the following rewritten paragraph:

Coils in the ignition operating circuit and the injection operating circuit discharge ~~discharges~~ remaining magnetic energy just after the coils are de-energized ~~disenergized~~. However, the energy is emitted as ~~a~~ heat and is not effectively used.

Please replace the paragraph beginning at page 4, line 7, with the following rewritten paragraph:

A first object of the present invention is to supply discharge energy effectively during a multiple discharges operation, and to reduce the size of an ignition

device.

Please replace the paragraph beginning at page 4, line 19, with the following rewritten paragraph:

Thus, the energy amount consumed at each discharge of multiple discharges operation is suppressed toward the minimum requirement, and the consumption of energy accumulated in the ignition device is appropriately controlled. As a result, discharge energy is efficiently consumed at the multiple discharges, thereby compacting the ignition device. Further, the number of multiple discharges is not restricted.

Please replace the paragraphs beginning at page 5, line 2, with the following rewritten paragraphs:

According to a second aspect of the present invention, an ignition operating circuit and an injection operating circuit are integrated with each other ~~together~~, and the ignition operating circuit and the injection operating circuit commonly share a function device used for both circuits.

Thus, the wiring pattern is simplified ~~easily made~~ between the ignition operating circuit and the injection operating circuit, and the ignition operating circuit and the injection operating circuit easily share the function device commonly used for both circuits. Therefore, circuit arrangement of ignition and injection systems and assembling procedure are simplified, thereby reducing the manufacturing cost.

Please replace the paragraph beginning at page 8, line 4, with the following rewritten paragraph:

In an ~~An~~ internal combustion engine, for example~~, is~~ a spark ignition 4-cycle 4-cylinder engine, ~~and~~ the ignition timing thereof is controlled by an ECU. In this engine, a plurality of electric discharges are carried out during one combustion cycle. That is, multiple discharge is executed.

Please replace the paragraphs beginning at page 9, line 2, with the following rewritten paragraphs:

A catalytic converter 22 containing three way catalyst is provided in the exhaust pipe 22. A limiting current Air/Fuel sensor 23 is provided at the upstream side of the catalytic converter 22. The A/F sensor 23 outputs a wide range and linear ~~linier~~ air-fuel ratio signal in proportion to the oxygen concentration in the exhaust gas (or the carbon monoxide concentration in unburned gas). Here, the A/F sensor 23 may be replaced with an O_2 sensor outputting different voltage signals between ~~in~~ a rich side and a lean side with respect to a theoretical air-fuel ratio.

An electromagnetic injector 24 is provided in each division pipe of an intake manifold. The injector 24 injects a fuel into the engine intake port by receiving an electric current. An ignition plug 25 is provided in each cylinder of the engine 10. New ~~A new~~ air supplied from the intake pipe is mixed with the fuel injected from the injector 24 at the engine intake port. When the intake valve 19 opens the intake port, the mixed air-fuel gas flows into the combustion chamber 18. The mixed air-fuel gas is ignited by the ignition plug 25 to be burned.

The ECU 30 includes a micro computer 31. Output signals from the intake air pressure sensor 14, the throttle sensor 15, the water temperature sensor 21, and the A/F sensor 23 are input into the ECU 30. Further, a pulse signal output every predetermined crank angle from a rotation number sensor 26 is input into the ECU 30. The micro computer 31 calculates an optimum fuel injection amount based on the miscellaneous parameters from these sensors, which shows an engine condition, and outputs the optimum fuel injection amount as an injection signal TAU into the injector 24. Further, the micro computer 31 calculates an optimum ignition timing based on the parameters, and outputs it as an ignition signal IGt into an igniter 41.

Please replace the paragraphs beginning at page 10, line 12, with the following rewritten paragraphs:

When the engine works, the power transistor 42 is on/off controlled in accordance with build-up/fall-down of the ignition signal IGt. When the power transistor 42 is energized, a primary electric current ii is charged into the primary coil 44 by vehicle battery voltage +B. When the power transistor 42 is de-energized ~~disenergized~~, the primary electric current into the primary coil 44 is shut off, and high voltage (secondary electric current i2) is charged into the secondary coil 45. The high voltage introduces an ignition spark between electrodes of the ignition plug 25.

According to the present embodiment, ~~the~~ multiple electric discharges in which a plurality of discharges are carried out during one combustion cycle are ~~is~~ executed. The multiple electric discharges are executed by repeating the on/off control of the power transistor 42 to repeat energizing/de-energizing ~~disenergizing~~ the primary

coil 44. That is, the multiple electric discharges <u>are</u> ~~is~~ done by controlling a current supply time and a current shut time for the primary coil 44. FIGS. 3A and 3B show pulses of a normal ignition signal IGt and of a multiple discharges ignition signal IGt, respectively. In FIG. 3A, one pulse signal is output during one combustion cycle. In FIG. 3B, a plurality of pulse signals are output during one combustion cycle.

An ignition control of the micro computer 31 will <u>now</u> be explained. FIG. 2 shows a flow chart of the ignition control. The micro computer 31 executes one routine in FIG. 2 every predetermined period (for example, every 10 ins). This execution <u>corresponds</u> ~~is corresponding~~ to <u>operation of</u> ignition control means and ignition timing retard means of the present invention. In the present embodiment, when the engine 10 cold starts, the ignition timing is controlled toward the retard side to early activate (heat) the catalytic converter 22. Further, the multiple electric discharges are carried out to suppress a torque fluctuation at the ignition timing retard control.

Please replace the paragraphs beginning at page 12, line 1, with the following rewritten paragraphs:

If the engine start is completed, the flow goes to STEP 104, and the ECU 30 calculates a basic ignition timing 0 BSE. Here, the ECU 30 determines whether the engine 10 idles or not based on the engine rotation number Ne. When the engine 10 idles, the ECU 30 calculates the basic ignition timing 0 BSE based on the engine rotation number Ne. When the engine 10 does not idle, the ECU 30 calculates the basic ignition timing 0 BSE based on the engine rotation number Ne and the intake air pressure PM by using a predetermined map. In general, when the engine rotates by

high speed, the basic ignition timing 0 BSE is set at the spark advance side. When the engine 10 just starts, in general, the basic ignition timing 0 BSE is set around BTDC1O^0 CA.

After that, the ECU 30 determines whether the early activation of the catalytic converter 22 should be done or not (STEP 105). For example, when all of the following ~~all~~ items are satisfied, the ECU 30 permits the early activation, but when~~.~~ ~~When~~ at least one of the following items is not satisfied, the ECU 30 prohibits the early activation.

Please replace the paragraph beginning at page 12, line 27, with the following rewritten paragraph:

When the ECU 30 determines that the early activation should be done, the ECU 30 executes an ignition timing control regarding the early activation (STEPS 106-109). When the ECU 30 determines it should not execute the early activation, the flow goes to END to finish the present routine.

Please replace the paragraphs beginning at page 13, line 14, with the following rewritten paragraphs:

After that, at STEP 107, the ECU 30 calculates θ ig by subtracting the spark retard correction θ RE from the basic ignition timing θ BSE (θ ig = θ BSE - θ RE), and saves ~~save~~ the θ ig into a predetermined address as new ignition timing.

At STEP 108, the ECU 30 sets the discharge interval and the number of

discharges during the multiple discharges operation based on the miscellaneous parameters. During the multiple discharges operation, it is necessary to attain a spark of each ignition and a dispersal of each flare. The ECU 30 sets the discharge interval and the number of discharges at each timing based on the ignition spark and flare dispersal. It is desired to set the discharge interval within a range 0.5-1.5 ins, and the number of discharges within 2-10 times. They may vary independently from each other. The ECU 30 sets the discharge interval in accordance with parameters such as engine rotation number Ne (or engine load), ignition timing (spark retard correction θ RE) and the like by using at least one of <u>the</u> relations in FIGS. 5A and 5B. When the discharge intervals set by FIGS. 5A and 5B are different from each other, the ECU 30 selects <u>the</u> longer one. The ECU 30 sets the number of discharges in accordance with parameters such as engine rotation number Ne (or engine load), ignition timing (spark retard correction θ RE), discharge interval and the like by using at least one of <u>the</u> relations in FIGS. 6A, 6B and 6C. When the number of discharges set by FIGS. 6A-6C are different from each other, the ECU 30 selects the largest one. The engine load may be attained based on the intake air pressure PM or an intake air amount.

Please replace the paragraphs beginning at page 14, line 17, with the following rewritten paragraphs:

FIG. 7 shows a relation between an engine crank angle and pressure inside the cylinder (pressure inside the combustion chamber 18). The pressure inside <u>the</u> cylinder reaches maximum pressure at <u>the</u> compression TDC position. After the pressure inside <u>the</u> cylinder starts to fall down, the mixed air-fuel gas is ignited to be

burned, so that the pressure inside the cylinder temporally rises due to the combustion pressure. When the crank angle closes to the compression TDC and the pressure inside the cylinder becomes higher, the energy level of the mixed gas increases, and the discharge energy needed for ignition varies. That is, as shown in FIG. 8, as the crank angle closes to the compression TDC where the pressure inside the cylinder becomes the maximum, the discharge energy needed for ignition can be small.

The ~~When the~~ discharge energy needed for ignition increases as the A/F ratio of the mixed gas becomes leaner. As is understood from comparing A/F = 17, A/F = 16, and A/F = 15 in FIG. 8 with each other, the discharge energy needed for ignition increases as the A/F ratio becomes leaner.

Please replace the paragraphs beginning at page 15, line 8, with the following rewritten paragraphs:

Thus, paying attention to that the discharge energy for ~~foe~~ ignition varies as described above, each discharge period during the multiple discharges operation is appropriately changed. According to the present embodiment, a relation between the crank angle position and the needed discharge energy is previously attained, and a relation between the number of discharges and the discharge period is patterned based on the relation between the crank angle position and the needed discharge energy.

For example, under the condition that ignition timing = ATDC1O^{0} CA, Ne = 1200 rpm, discharge interval = 1 ms, and the number of intervals = 5, the pressure inside the cylinder is 1.0 MPa at the first discharge. After that, the pressure inside the

cylinder decreases to 0.4 MPa ~~Map~~ at the fifth discharge by repeating discharges every 1 ms. In this case, the optimum discharge period is set as shown in FIG.9. Examples are described hereinafter.

(1) When A/F = 17, the first through fifth discharge periods are set to "0.16-0.37 ms".

(2) When A/F = 16, the first through fifth discharge periods are set to "0.12-0.32 ms".

(3) When A/F = 15, the first through fifth discharge periods are set to "0.07-0.20 ms".

These discharge periods are the minimum requirement for attaining the ignition energy. When the ignition coil 43 accumulates sufficient energy, the discharge periods had better be set appropriately longer for attaining ~~a~~ combustion stability of the engine 10.

At STEP 109 in FIG. 2, each discharge period is calculated based on ignition timing, discharge interval, the number of discharges, A/F ratio and the like. When a multiple discharges operation is executed after the compression TDC, discharge period is gradually set longer as the electric discharges are repeated.

Please replace the paragraphs beginning at page 16, line 16, with the following rewritten paragraphs:

FIG. 10 is a time chart explaining the multiple discharges operation. FIG.

10 shows an example in which ~~that~~ the spark timing is set ATDC10^0 CA.

The electric discharges are repeated five times in accordance with the ignition signal IGt, and the accumulated energy in the ignition coil 42 is consumed at each electric discharge. Each discharge period is, as denoted by Ti, T2, T3, T4 and TS in FIG. 10, gradually set longer. Here, remaining energy in the ignition coil 43 can be consumed at the last (fifth) discharge, so that the fifth discharge period TS need ~~needs~~ not be accurately controlled. That is, the last (fifth) discharge period TS has only to be at least longer than the above described discharge period.

According to FIG. 10, the energy amount at each electric discharge is always over the required energy amount for ignition (slant lines area in FIG. 10), and sufficient energy remains even at the last discharge. Here, the energy is not consumed excessively, thereby suppressing the energy from being wasted.

As described above, according to the present embodiment, when a multiple discharges operation is executed, the discharge period is set shorter as discharge timing more closes to the compression TDC while chasing transition of the pressure inside the cylinder. Thus, the energy amount consumed at each discharge of the multiple discharges operation is suppressed toward the minimum requirement, and consumption of energy accumulated in the ignition coil 43 is appropriately controlled. As a result, the discharge energy is efficiently consumed at the multiple discharges, thereby compacting the ignition coil 43. Further, the number of multiple discharges is not restricted.

The ECU 30 calculates the discharge period based on the pressure inside the cylinder and A/F ratio of the mixed gas, and sets the discharge period longer as the

mixed gas is leaner. Thus, the ignition control is carried out more accurately.

Please replace the paragraph beginning at page 17, line 25, with the following rewritten paragraph:

The multiple discharges are executed in accordance with spark retard control at the cold start of the engine 10. Thus, the catalytic converter 22 is activated early ~~activated~~. An engine combustion condition, which tends to be unstable due to the spark retard, is stabilized. The discharge energy of the ignition coil 43 is appropriately controlled.

Please replace the paragraphs beginning at page 18, line 5, with the following rewritten paragraphs:

In the first embodiment, the multiple discharges operation is applied at the cold start of a port injection type engine. According to the present second embodiment, the multiple discharges operation is applied to a cylinder inside injection type engine. The multiple discharges operation is executed for igniting stratified mixed gas with certainty at stratified combustion of the engine to prevent an accidental fire.

In the second embodiment, a high-pressure swirl injector is provided under the intake port of the engine 10 in FIG. 1. High pressure fuel is injected from this injector toward the top of the piston inside the combustion chamber. The piston includes a concave portion at the top surface thereof. Fuel injection flow from the injector is led along the inner periphery surface of the concave portion toward the spark point (tip end) of the ignition plug 25.

FIG. 11 shows a flow chart of the ignition control. This execution ~~is corresponding~~ corresponds to an ignition control means of the present invention. The micro computer 31 starts to execute the control at ignition timing.

In FIG. 11, engine rotation number Ne and intake air pressure PM (engine load) are input into the ECU 30 (STEP 201). Next, the ECU 30 determines whether a driving condition is within the multiple discharges range or not. That is, the ECU 30 determines whether both engine rotation number Ne and engine load are under predetermined values or not, based on a discharge range map in FIG. 12. As shown in FIG. 12, the multiple discharges range defines a range where both engine rotation number Ne and engine load are under predetermined values respectively.

When the ECU 30 determines it is not within the multiple discharges range, but within the single discharge range, the flow goes to STEP 203 to discharge only once. That is, after normal primary electric current ii is normally shut off, the ECU 30 keeps de-energizing ~~disenergizing~~ the power transistor 42 (see FIG. 1) so as not to carry out the multiple discharges operation.

When the ECU 30 determines it is within the multiple discharges range, the flow goes to STEP 204. At STEP 204, the ECU 30 calculates each discharge period at the multiple discharges operation. The ECU 30 calculates each discharge period based on the above described ignition timing, discharge interval, the number of discharges, A/F ratio and the like. Here, the discharge period is set shorter as discharge timing more closes to the compression TDC while chasing transition of the pressure inside the cylinder.

At STEP 205, after the primary electric current ii is normally shut off, the

power transistor 42 is repeatedly energized and de-energized ~~disenergized~~ every constant interval to allow the ignition plug 25 to repeatedly discharge. After that, at STEP 206, the ECU 30 determines whether the number of discharges has reached a predetermined number or not, and continues to execute multiple discharges operation until the number of discharges reaches the predetermined number. Here, the number of discharges may be set based on relations in FIGS. 6A-6C as in the procedure in FIG. 2.

As described above, according to the present second embodiment, the discharge energy is effectively consumed by ~~at~~ the multiple discharges as in the first embodiment, thereby compacting the ignition coil 43. Further, the number of multiple discharges is not restricted. Especially in the cylinder inside injection type engine, even when timing of relatively rich mixed gas (stratified mixed gas) reaching the ignition plug 25 deviates from the calculated timing a little, the multiple discharges operation is executed for igniting the mixed gas with certainty to prevent an accidental fire.

Please replace the paragraphs beginning at page 20, line 23, with the following rewritten paragraphs:

That is, the discharge period is not uniformly changed in accordance with the pressure inside the cylinder and advance amount or retard amount from the compression TDC. The discharge period is restricted by a predetermined guard value allowing the discharge period to be the minimum period. In this case, since the minimum discharge period is restricted, the required energy for combustion is attained with certainty, thereby stabilizing the combustion. Further, the discharge period may be constant regardless the pressure inside the cylinder within a predetermined crank angle

range at least including the compression TDC.

According to the above described embodiments, each discharge period is calculated based on the ignition timing, discharge period, the number of discharges, A/F ratio and the like. Alternatively, the discharge period may be set based on at least ignition timing and the number of discharges for substantially chasing the transition of the pressure inside the cylinder.

According to the above described embodiments, the discharge period at a multiple discharges operation is set based on A/F ratio, and these are patterned. Alternatively, only one data A/F = 17 out of each A/F data may be applied. That is, the discharge period is set longest when A/F = 17, out of A/F = 15, 16, 17. Thus, when the data A/F = 17 is used, sufficient discharge energy can be attained even when A/F is less than 17 (rich side more than A/F = 17).

According to the second embodiment, as described in FIG. 12, the multiple discharges range is defined by engine rotation number Ne and engine load, and the ECU determines whether the execution of a multiple discharges operation should be done or not. Alternatively, only engine rotation number may define the multiple discharges range. That is, the multiple discharges operation is executed when the engine rotation number is less than a predetermined rotation number (low, medium rotation range). The multiple discharges operation is not executed when the engine rotation number is more than the predetermined rotation number (high rotation range). In this case, the discharge period is short and timing of stratified mixed gas reaching the ignition plug deviates from the calculated timing a little, so that the multiple discharges operation at the high rotation range is stopped.

Further, only engine load may define the multiple discharges range. That is, in the cylinder inside injection gasoline engine, combustion is changed into homogeneity combustion when an engine load becomes high, and homogeneous rich mixed gas fills ~~fulfills~~ the combustion chamber at the homogeneity combustion. Thus, there is no problem that timing of the mixed gas reaching the ignition plug deviates from the calculated timing. Accordingly, the multiple discharges operation is not executed within a load range where single discharge attains sufficient ignition performance like the homogeneous combustion, and the multiple discharges operation is executed within other engine load ranges.

Please replace the paragraphs beginning at page 22, line 25, with the following rewritten paragraphs:

According to the above described embodiments, when the multiple discharges operation is executed, the discharge interval and the number of discharges are variably set based on engine rotation number, engine load and ignition timing by using relations in FIGS. 5 and 6. Alternatively, the discharge interval may be set shorter and the number of discharges may be increased as A/F ratio becomes leaner.

Further, the discharge interval may be set shorter and the number of discharges may be increased as the ~~a~~ time passed from the engine start becomes longer. At least one of discharge interval and the number of discharges may be fixed.

According to the aspect of the present invention, the discharge period is changed in accordance with pressure inside the cylinder (pressure inside the combustion chamber). Thus, it is desirable to monitor the transition of the pressure

inside <u>the</u> cylinder and to correct the discharge period one by one based on the transition. That is, when the transition of pressure inside <u>the</u> cylinder is detected, the ECU 30 had better set a learning value corresponding to the transition and correct the discharge period by using the learning value. For example, the pressure inside <u>the</u> cylinder reduces, the ECU 30 sets a positive leaning value to correct the discharge period longer. In this way, <u>the</u> multiple discharges operation is appropriately executed even at the transition.

Please replace the paragraph beginning at page 24, line 17, with the following rewritten paragraph:

The structure of the ignition control circuit 61 will be explained. The battery voltage VB is boosted at a booster circuit 70, and is charged into a condenser 72 through a diode 71. The booster circuit 70 includes a coil 73, a switching element 74, and a resistance 75 being connected in series. An ignition control circuit (ECU) 76 controls the on/off of the switching element 74 to boost the discharge voltage of the coil 73. While the switching element 74 is made on, the booster circuit 70 supplies an electric current into the coil 73. The ECU 76 monitors the electric current value through <u>the</u> terminal voltage of the resistance 75, and controls the switching element 74 to be off when the electric current value becomes a predetermined value. The ECU 76 repeats this operation to boost the discharge voltage of the coil 73 and charge it into the condenser 72. The ECU 76 monitors charged voltage in the condenser 72. When the charged voltage reaches a predetermined voltage, the ECU 76 controls the booster circuit 70 to stop boosting.

Please replace the paragraph beginning at page 26, line 22, with the following rewritten paragraph:

A switching element 93 energizes and de-energizes ~~disenergizes~~ a coil 62a of the fuel injection valve 62, and is operated by the single stable multiple vibrator 90. When the output of the single stable multiple vibrator 90 is high, the switching element 93 is energized, and charged voltage in the condenser 92 is impressed on the coil 62a of the fuel injection valve 62. simultaneously, the battery voltage VB supplied through a diode 94 is also impressed on the coil 62a. A switching element 95 and a diode 96 are arranged in parallel in the circuits of the diode 94 and the switching element 93. When the switching element 95 is energized, the battery voltage VB is impressed on the coil 62a of the fuel injection valve 62 in the circuits of the switching element 95 and the diode 96.

Please replace the paragraph beginning at page 28, line 25, with the following rewritten paragraph:

According to the above described third embodiment, since the ignition operating circuit 61 and the injection operating circuit 63 are arranged on the single substrate, the wiring pattern is easily made between the ignition operating circuit 61 and the injection operating circuit 63, and the ignition operating circuit 61 and the injection operating circuit 63 commonly share the battery stabilizing circuit 64. Therefore, the circuit structure of the ignition and injection systems, and the assembling procedure are simplified~~,~~ thereby reducing the manufacturing cost.

Please replace the paragraph beginning at page 30, line 21, with the following rewritten paragraph:

Further, as shown in FIG. 19, the ECU changes the pulse durations of the ignition determination signal WTG and the injection determination signal WTJ in accordance with ignition period and injection period. The signal determining circuit 105 determines a pulse duration (ignition period) of the ignition signals IGO1-1G04 in accordance with the pulse duration of the ignition determination signal WTG, and determines a pulse duration (injection period) of the injection signals IJO1-1J04 in accordance with the pulse duration of the injection determination signal WTJ. Here, the above-described signal determining circuit may be constructed by a theoretical circuit.

FIG. 20 is a time chart showing actual ignition signal and injection signal at an independent injection of intake pipe injection. IGO1-1G04 denote ignition signals of first through fourth cylinders, respectively. IJO1-1J04 denote injection signals of first through fourth cylinders, respectively. Here,the first cylinder defines a cylinder firstly injecting and igniting out of the four cylinders. Signals are output in the ~~as~~ following order ~~orders~~;

Please replace the paragraph beginning at page 33, line 14, with the following rewritten paragraph:

In the present embodiment, the determining method for the signals from the signal determining circuit 55 may be changed appropriately. For example, cylinder

determination and ignition/injection determination may be carried out based on pulse duration or pulse number during a predetermined period of output signal from the ECU.

Please replace the paragraph beginning at page 34, line 5, with the following rewritten paragraph:

According to the present fifth embodiment, a piezoelectric element is used for operating the fuel injection valve 111. When the fuel is injected, the piezoelectric element is energized to allow the fuel injection valve to open the injection port. When the fuel injection is finished, the piezoelectric element is de-energized ~~disenergized~~ to allow the fuel injection valve 111 to close the injection port. In the injection inside cylinder type engine 110, since the injection port of the injection valve 111 exposes to the inside of the cylinder, combustion pressure inside the cylinder acts on a needle of the injection valve 111, and the combustion pressure acts on the piezoelectric element through the needle. Thus, electric voltage is introduced in the piezoelectric element in accordance with the increase of fuel combustion pressure inside the cylinder.